minimise thermal background, selectable pupil stops are included which effectively undersize the secondary mirror and obscure the virtual image of the Cassegrain hole. Precise alignment of INGRID to the WHT science beam is achieved through a retractable pupil imaging mechanism that will allow alignment during the day.

A filter set is available which includes the standard Z, J, H, K and Ks broad band and 10 narrow band filters (see WWW page for details). All of these filters were purchased through the Gemini filter buying consortium and hence will provide INGRID users with data that is completely comparable to data obtained at many of the 8 m class telescopes. The filters are of excellent optical quality and are fully adaptive optics compliant for use with NAOMI.

During runs at the folded Cassegrain focus, INGRID will use a closed cycle cooler to remain cold. For rapid cool-downs and completely vibration free observations during NAOMI runs, we will use liquid nitrogen cooling. There are several read-out modes available for INGRID but all feature a full frame readout in 1.5 seconds. The typical readout mode will be double correlated sampling, but others include windowing (for high-speed observations), multiple non-destructive reads (for reduced read noise), image co-average (for reduced dead-time) and movie mode (for target acquisition). The dark current is low and as the read-noise of a double correlated sample is low (expected to be ~10 e^- or lower per read), most exposures will be sky noise limited. All images are automatically displayed on an IRAF display tool that also plots the seeing and sky background against time. Pixel saturation is notified to the observer via a colour change of the affected pixels as seen on the display tool.

Estimates of the throughput of INGRID suggest a similar sensitivity to that of WHIRCAM but with a much lower thermal background and a gain in sky coverage of a factor greater than 17. The limiting magnitude, based on a 9000 second on-sky observation of a stellar source in 1″ seeing, is 24.3, 23.1 and 22.1 mag at J, H and Ks respectively. Observing is facilitated via the use of pre-prepared observatory and user generated UNIX scripting.

The potential science applications for INGRID are numerous, especially when integrated with NAOMI. Applications include quasar host detection, probing the centres of active galactic nuclei, brown dwarf detection, planetary nebulae, young stellar objects, crowded field photometry, etc. At the folded Cassegrain focus INGRID will be able to improve on the observations of WHIRCAM as well as providing the opportunity to observe from U to K. As INGRID will typically be mounted cold at the folded Cassegrain focus, target of opportunity observations (such as gamma ray bursts, supernova, etc.) are ideal for this instrument. ¤

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Super Cool Technology

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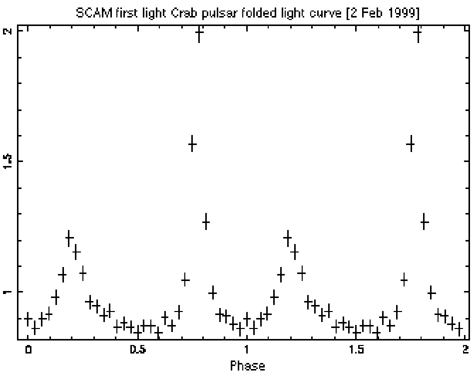
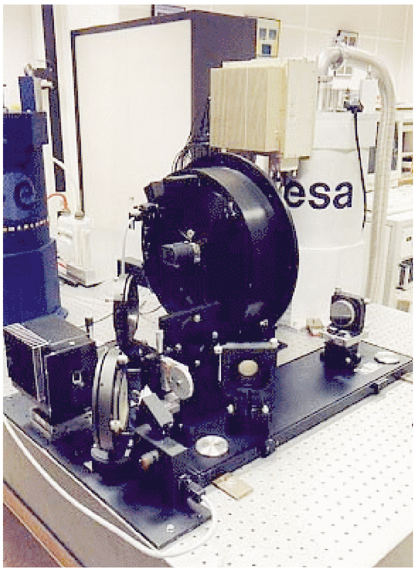
Historically, technological advances have literally opened up the sky for groundbreaking discoveries in astronomy. Such examples of this are the impact of CCD technology on photon-starved spectroscopy and the extension of the observable universe through infrared detectors. We here at Isaac Newton Group are privileged to be part of just such a technological advance, which promises to allow a more complete understanding of the universe.

On the evening of February 2nd this year, 'First Astronomical Light' was seen by a novel photon detector device, an array of superconducting tunnel junctions. These junctions, arranged into a small array, allowed us to measure simultaneously the time of arrival, the energy, and the spatial distribution of photons arriving from the Crab nebula. In contrast to current astronomical detectors, the Superconducting Tunnel Junction (or STJ) allows these three crucial parameters to be measured by one detection device in real time with very good quantum efficiency across a large wavelength range. The results of this first light technology proving run are published in *Astron & Astrophys*, **346**, L30 (1999). Figure 1 shows an extracted light curve of the Crab pulsar derived from this work.

A dedicated team of scientists and engineers at the Astrophysics Division of the European Space Agency (ESA) have brought this technology to fruition by adapting materials and techniques from X-ray detector technology to the visible and infrared spectrum. The instrument built by this team to demonstrate the STJ technology is called S-CAM (Figure 2) and combines the 6×6 pixel STJ array with stand alone support and acquisition equipment. This instrument couples to the Ground Based High Resolution Imaging Laboratory (or GHRIL) focal station of the William Herschel telescope and provides a limited field of view of 4×4 arcseconds within 36 pixels.

The principle of operation for the STJ detector, electron tunnelling, is exploited by sandwiching a thin insulating layer between two superconducting layers with attached electrodes. The energy gap of the superconducting material determines the intrinsic energy resolution as well as the operating temperature of the detector. In the S-Cam case, with Ta based STJs, the intrinsic resolving power ($\Delta\lambda$ fwhm) corresponds to 17 at λ = 500 nm, at an operating temperature of about 300 mK. The actual instrument energy resolution is degraded by





Figures 1 and 2. The Crab pulsar light curve (above) and the S-CAM Instrument (right).

electrical and thermal background induced noise. By applying a small bias voltage across the junction and a suitable parallel magnetic field to suppress the Josephson current, an electrical charge proportional to the energy of the perturbing photon can be extracted from the device.

The introduction of the STJ as an astronomical detector is in many ways the natural next step beyond the CCD detector. In the latter silicon-based devices, the band gap between the ground state and the state excited by the absorption of an optical photon is comparable to the photon energy. As a consequence, only a single electron is extracted from the detector per absorbed photon irrespective of its energy. In contrast, the equivalent energy gap of superconducting niobium is some three orders of magnitude lower, which means that of the order of one thousand electrons are released per detected optical photon. More importantly the amount of charge generated is proportional to the energy of the absorbed photon. Thus by measuring the charge released by each detected photon, these can be sorted in energy to an accuracy limited by intrinsic detector resolution and by any additional electrical and thermal background induced noise. For a given junction geometry, the achievable wavelength resolution $\Delta\lambda$ varies as $(\lambda^{3/2})\times(\delta^{1/2})$, with δ being the superconductor energy gap. STJ based detectors have demonstrated the capability to provide spectroscopic information over a large energy range, from the NIR to the UV. By arranging a number of STJ devices into a two dimensional array, a true 'three dimensional' astronomical detector can be constructed, whose output is not just the number of photons registered in each pixel of the image, but their distribution in energy throughout the UV, visible and near-IR.

Having achieved successful first light, the team at ESA is now enhancing the S-CAM in light of the experience gained from the February run. These enhancements among other things include a slightly larger field of view (6×6 arcsec.) and increased bandwidth in the electronic processing to allow a higher dynamic range of stellar magnitudes. The awaited return of S-CAM to the WHT will take place in early December this year. It is anticipated that in parallel to the science projects to be conducted with S-CAM, development work will continue on the detector devices and their application to astronomy. In the forthcoming future this will allow a common user instrument to be offered by the ING with this unique detector technology at the WHT.

The impact that STJ detector technology will have on instrumentation for astronomy will be significant. Having the detector quantify photon energy theoretically removes the requirement for much of the optical processing of the instrument thus allowing all photons collected by the telescope to be gainfully measured, thus improving sensitivity dramatically. Time resolution photometry at different wavelengths becomes a parallel dream! Wide band imaging, from UV to IR, possible with just one detector! The potential of this technology lies in wait to reveal Nature's true colours!

Figure 3 shows the spectrum obtained with a Ta based device by setting the monochromator at 1.2 microns and removing the order separating filter. The spectrum spans wavelengths from 300 nm in the near UV to 1.2 microns in the near-IR, and shows the simultaneous detection of four spectral orders of the monochromator output.

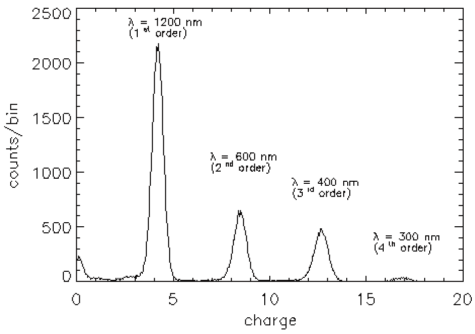


Figure 3. Wide band response of STJ.

Further information on STJ detectors and S-Cam can be found at the following URLs:

http://astro.estec.esa.nl/SA-general/Research/Stj/STJ_main.html

http://astro.estec.esa.nl/SA-general/Astronews/37-html/an37.html#stj

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